Didactic Scenarios and ICT: A Good Practice Guide

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Abstract. In this paper a 'good practice guide' is presented for creating Didactic Scenarios (D.S.) with the support of ICT. This guide is based on: a) empirical data collected during longitudinal training programs addressed to secondary education teachers, b) observation of the way ICT is used in both levels of education and c) modern didactical theories.

Keywords: Didactic Scenarios, ICT.

1 Introduction

The term *Didactic Scenario* (D.S.) refers to a relatively complete description of a teaching lesson including not only the teachers' actions but also the expected reactions of the students. Moreover, it includes the justification of the teachers' didactical choices. As we shall explain below, D.S. differs from a lesson plan, its description or its content. D.S., as both theoretical and practical concept, constitutes an issue that has been the center of discussion in the educational community for a long period. Recently, the rapid development of ICT in education forced teachers to reconsider the lessons' design since ICT have to be incorporated in modern educational scenarios. In Greece, there exists one more reason to keep this discussion since teachers' training on ICT during the last years highlighted a series of questions asking urgently their answers: What exactly is D.S.? How is it constructed? How this could be used? The whole situation becomes more confusing since experts' opinions do not coincide. In this paper we propose a good practice guide for constructing D.S. using ICT. This guide is the result of a synthesis of different published views on the topic [3], [5] adapted mainly (but not exclusively) in didactic methods relevant to Math, Science, Informatics. We combined elements that seem to be common in the didactic methodology of different learning objects. In its initial version this guide was focused on math teaching [3]. However, we gradually realized the existence of elements that were common in a variety of lessons that are taught in school and therefore we were directed to a guide that could fill the demand for more and different lessons. Our intention is to propose this guide as an everyday "tool" that will be used not in an 'algorithmic' way nor as a 'recipe' for producing scenarios and lesson plans. On the contrary, its usage presupposes that the teacher is aware of the learning object and the way students learn. Some features necessary for constructing and applying a modern D.S. are highlighted.

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2 Conditions for Creating and Designing D.S.

Our starting point is the constructivist hypothesis that the knowledge is constructed by the students themselves via their interaction with the *milieu*. Thus, the students grasp the new information, transform older concepts, and create a new set of concepts, relations and properties. In this context, the students' activities take meaning in a very specific manner and the teachers' choices are very different compared to the ones taken in the traditional lessons. For example, it is likely for students' errors to express a previous knowledge that has not been properly transformed and therefore these errors are a clue for teachers' future actions. Teachers must take seriously account of these errors while interacting with students. A set of activities must be suitably organized so as for the students to transform their existed knowledge to a new, more refined one. An important parameter for obtaining this is the so-called *open problems*. The teacher poses the problems and the students have to ask for relevant information, to combine them, to apply formulas or methods, to co-operate in order to find the solution. ICT is used in this context as part of the milieu the students interact with, as a set of various cognitive tools that are used in the problem solving process and this is the rationale we adopt in this guide.

D.S. (or **Didactic Situation** in Math Education [2]) could be defined as the description of a teaching process focused on a specific cognitive object, with specific teaching aim, including specified didactic principles and practices. The most important in D.S. is rather the route of the students, than the linear description of teachers' actions. Various parameters are included in modern D.S. such as interaction and roles of participants, students' concepts and expected errors, didactical obstacles, and so on. In such a teaching approach it is possible to combine more than one source (variety of different software, notes, instruments in laboratory, geometrical instruments) so as to obtain a learning outcome. Elaborating a scenario means that there are some critical points that must be handled carefully:

(1) Avoidance of meaningless verbalism. Very often the proposed scenarios include parts that systematically lead to the repetition of stereotypical phrases of questionable usability. As a typical example, one can think about the almost ritual reference to "*constructivist theories of learning*", which is repeated stereotypically in a large number of scenarios produced by the teachers as a typical "duty".

(2) The feasibility and usability of the D.S. The D.S. has to be feasible, to describe situations able to be realized in the given schooling time and context. Moreover, it is not proper to make tremendous effort or to waste a lot of time for creating a scenario.

(3) The most important when creating a scenario is the negotiation of its "weaknesses". For example, creating a new D.S. out of nothing (*creation ex nihilo*).

3 Configuration of a D.S.

3.1 Starting a Scenario

There are several ways to start from zero a D.S. so as to teach a specific concept. We could mention some of them: i) presenting the circumstances that resulted to adopting this concept. For example, the need to redefine the boundaries of the fields in Egypt, every time Nile flooded, resulted to the development of the concept of area. In Science, the history of astronomy or of the atoms as basic units of matter, are some typical examples of unsolved problems that made necessary to invent new theories. What is common in these cases is the presentation of a concept or a theory, as a *tool* which resolves and gives meaning to a series of problems. ii) using Internet as a source that offers data relevant to the concepts (historical elements, complete lesson plans, applets, etc). iii) starting from the students' difficulties (systematic errors, misconceptions), the teacher could design a lesson aiming to provoke a socio-cognitive conflict via a didactic situation that leads to dead end. Then the only way to overcome the conflict is the new concept or method that was the teacher's intention.

3.2 Epistemological Approach – In the Context of a "School Epistemology"

The importance of the concepts taught in school is tightly connected with the present opinion about the status of these concepts in the knowledge system that is "transmitted" by the school. The relative value of these concepts is determined by a rather complicated framework of didactic principles which in any case change very often. For example, some concepts or methods might be extremely important during a historical (school) period of time and literally disappear in another. Absolute value in mathematics, the famous "simple method of three" and the systematic memorization of grammatical rules are some typical cases of didactic issues and practices that disappeared because they had been considered as old-fashioned from a modern didactic point of view or because the progress in the domain made them inconsistent with the present scientific or didactical ideas. In other cases, the significance of the taught concepts depends on their conceptual connection with other ones and on their future usage: for example, the teaching of the syntax of the Ancient Greek Language takes place in a certain grade and it is important since the same students will use the syntax in a subsequent grade for translating and understanding ancient Greek texts. In Mathematics also, the Pythagorean Theorem is connected with square root and irrational numbers in the 8^{th} Grade, but the extensions of the same theorem (side of a triangle that is opposite to an acute or an obtuse angle) are taught later on the 11^{th} Grade. It is vital for the teacher to be able to understand this kind of relationships or to know how to reach the relevant information.

3.3 Extensions

In the school reality all the concepts are connected directly with others. So, it is necessary for the teacher to be aware of the potential extensions of each concept. Is it possible for the specific activity to be the origin for other, more partial activities that broaden the initial one? Is it possible to use this method or this result for another problem or activity? Is it possible for the specific activity to activate the students' questioning towards a further examination? For example, a scenario based on the question whether the perpendicular bisectors of a triangle are passing or not through the same point, could be broadened for the case of this point to be inside the triangle or on one of its sides.

3.4 Predicting Difficulties

D.S. must incorporate all of the students' usual difficulties relevant to the specific concept. For example, most of the students believe that $(A+B)^2=A^2+B^2$ and "forget" the double product of the terms. (Probably) this is due to the fact that many mathematical properties obey the "linearity" rule F(A*B)=F(A)*F(B). In Science very often students believe that if no force is applied to a moving object, then it will stop moving or that heavier objects are falling more quickly than lighter ones. Generally, all these students' wrong ideas must be part of a D.S. as they can play a vital role in the development of these scenarios. Educational software could help in a variety of ways for exceeding these mistaken concepts. Simulations, for example, allow the repetition of phenomena and their study in different circumstances. This creates an obvious distance between what the students predict and what 'really' happens in the (simulated) reality.

3.5 The Rationale of Using Digital Systems

Availability of adequate digital infrastructure is not itself a reason for materializing a teaching activity based on technology. Actually, a combination of the current technological infrastructure and the innovative organizing of the lesson is required. Otherwise, the digital infrastructure is reduced just to support a 'traditional' lesson. For example, asking information on the Internet is an important activity that is more complex compared to using 'classic' sources such as newspapers and encyclopedias. The students must be able to: search and choose among the tons of data the ones that are useful; check whether they are valid and up-to-date; be aware and sensitive about ethics and copy-right issues. This means: a) lesson's organizing in a completely new way (compared to the traditional one) and b) equipping students with certain skills. It must be avoided also using technology in favor of lessons that have a traditional character. Webquests constitute a typical example. As a teaching method they present a lot of attractive features. However, for the sake of saving time, they easily are converted to a set of completely guided activities. Consequently, the assessment of choice of the used software must be based not only on its innovative character but on its estimated didactic effectiveness. It is the rationale of the teaching that justifies the usage of digital systems rather than the opposite. On the other hand, it is possible to face additional problems when using some software. It will be necessary to waste time for making the students familiar with the specific environment. Another potential reservation concerns the possibility for the students to acquire a limited concept image. Sometimes the usage of digital systems gives emphasis to some aspects of a concept when there has not been established other prerequisite knowledge [6]. Or, it is likely for a limitation to some skills to occur. Resorting, for example, to handheld calculators in the very early grades may suspend their ability for mental calculations. It is also known that the immediate feedback the user receives through the interface prevents or strengthens a problem solving process. But this feedback may cause misconceptions to the students for some concepts. Finally, it is worthwhile mentioning that sometimes it is the software or the digital environment itself that causes mistaken conceptions to the students.

3.6 Teaching "Noise"

By this term we refer to undesirable side effects that could overshadow the real object of a lesson. There exist, for example, learning objects that demand the usage of external sources or instruments (geometrical instruments, blackboard, additional written texts). In this case it is frequent for the students to waste time trying to use these instruments. However, the usage of technology tends to minimize some kinds of "noise"– wasting valuable time for making long calculations is minimized when using digital systems that make these calculations instantly.

3.7 Usage of Additional External Sources

As it has already been mentioned above, the teacher must be aware of the existence of sources (the Internet, for example) that could allow him: to retrieve information relevant to the taught concept; to find -if possible- additional teaching material, notes, reports from similar teaching efforts, etc.

3.8 Multiple Representations – Multiple Approaches

Modern software allow multiple representations of concepts, relationships and evolution of phenomena. For example, using simulation software for studying various phenomena (car crash, evolution of the fauna in an ecosystem), the user can follow the evolution of the (simulated) phenomenon as also the evolution of some (qualitative or quantitative) parameters in real time in the form of tables, graphs, bar charts and so on. So, a D.S. must take account of this dimension. Most of the times, while teaching a lesson, for 'economy' reasons the presentation of the new concepts is realized using just one representation, restricting thus the complete approach of the phenomenon. Another aspect of the issue is that digital technology could contribute to redefine the content of the school lessons: the global spreading of graphing calculators facilitated the readjustment of lessons such as Algebra and Science so as to incorporate graphs in a greater extent than before. Presenting concepts, relationships, phenomena in multiple representational frameworks means that it is possible to obtain deeper and more complete understanding of both the phenomenon ant the used 'tools' (i.e., tables, diagrams, algebraic expressions, etc.).

3.9 Underlying Learning Theories

The underlying teaching and learning theories the teacher adopts (which very often are not explicit) determine decisively the lesson's organizing. Even though most of the modern software refer to constructivism and explorative learning, this does not mean they adopt them. Teacher's intention to design a specific activity could be ruled by theoretical principles that by-pass the ones that characterize the software itself. Thus, it is possible, for an open software with so many capabilities to be used exclusively for drill and practice activities guided completely by the teacher. Similar phenomena could be met in conservative educational systems, like the Greek one, that do not adopt easily innovative practices. This issue has to be examined thoroughly by the teacher, since it is directly connected to his personal opinions and theories.

Moreover, the teacher has to reflect on whether the way he organizes the lesson corresponds to more general views, concerning the organizing of teaching or the way students learn.

3.10 Change in Lesson's Organizing and in Concept's Meaning

Digital educational environments allow innovative teaching approaches. The case of 'rigorous proof' in teaching Geometry is a typical example. Modern software allow verification (but not a rigorous proof) of conjectures through experimentation. This changes radically teacher's capabilities since s/he is able now to ask the students to ascertain initially (by trials) the truth of a proposition and later to prove it. Furthermore, the various environments of communication and social networking and the web 2.0 environments, create new kinds of text and new sociolinguistic practices [4] and offer new possibilities in language teaching unexplored in a great extend. All these changes result to restructuring lessons and giving different meaning to concepts and methods that are negotiated during teaching.

3.11 Didactic and Computational Transposition

The term 'transposition' when used in Education describes all the changes in the concept's meaning that take place during the 'transfer' of the concept ('transposition') from its initial science domain to Education. In analogy, 'transposing' concepts of the Science domain to digital environments [1] means their transformation in a certain degree: In Dynamic Geometry systems, straight lines include finite number of pixels rather than infinite number of points; in a more general way in a digital system the concept that is to be taught is usually mediated. The modern educational software interface allows the management of microworlds, which represent or simulate a system. So, although the user has the feeling that s/he handles a microworld directly, in actual fact s/he handles indirectly a particular materialisation of the simulation of a system. In Geometry, for example, using different software, the students could have at first glance the same shape (triangle or rectangle) in the interface which however, behave differently in each environment. This is an aspect that must be taken seriously into account when a D.S. in a digital environment is designed.

3.12 Didactic Contract

Didactic Contract [2] could be defined as the set of teacher's behaviors expected by the student and vice versa, in the context of a didactic interaction. The term *behavior* refers mainly to actions and reactions relevant to teaching. Here is a simple example: If the teacher poses an unsolvable problem and avoids informing the students, this could cause objections from the part of the students. The students consider this behavior as a violation of some implicit rules that constitute part of the so-called didactic contract. This contract is not explicitly expressed and becomes noticeable whenever it is violated. Simulating real phenomena in the classroom could influence the way the students' answers become valid. Instead of having the teacher to accept or reject them, it is possible for the system to make the decision according to whether these answers fit to the simulated system (change of didactic contract). ICT's usage in the teaching process always cause changes to the invisible but powerful contract. So, it is necessary for the teacher to take account of it and to adapt his lesson accordingly.

3.13 Feasibility and Lesson Organizing

Depending on the specific D.S., teachers have to handle the number of students, the number of the available computers, the way of working (individually, in groups), time (how many hours?). There are also some extra factors that must be taken into account. For example, the usage of two or more software in tandem in one teaching hour is desirable in the most of the cases but it is time consuming. The teacher has to make some choices so as to make his D.S. as far as possible realistic.

4 Instead of Conclusions

The "good practice guide" presented here is not considered as a complete one. We omitted some of its parts considered more than obvious (the lessons' content) as also parts that are important but they refer to more general issues such as interdisciplinary aspects, didactical methods, etc. Besides, what presented here is not always obligatorily included in a D.S. since some of its parts won't be able to be applied in a specific scenario. It is obvious also that there exists a partial coverage among the parts of the guide since their boundaries are not strictly defined. It seems finally that there exist some characteristics that are common in the teaching process no matter what the taught lesson is. This means that the impact of ICT on teaching is neither temporary nor connected exclusively with only some categories of lessons such as Math or Science. This impact is equally important for a variety of lessons strengthening thus the suspicion that ICT's impact is deeper than imagined.

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